Title
How experimental research in agriculture has gone from lab to field

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Publication Date
2020-03-01

DOI
10.1016/j.worlddev.2019.104782

Peer reviewed

Jumping the fence: How experimental research in agriculture has gone from lab to field

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November 2019

Abstract

Agriculture has a long tradition of randomized experiments in the research station and of comparative demonstration plots under scientist control. The BDK Nobelists have pioneered randomized field experiments under agency control to fight global poverty, thus making behavior, contextual circumstances, and institutional constraints key determinants of outcomes. In agriculture, experimentation has massively responded in jumping the fence from lab to field, with already major advances as to how to better use agriculture for development. We document how this has happened and how the methodology of field experiments has to be adapted to perform in the challenging context of developing country agriculture.

Introduction

There has been a long and unique tradition in agriculture of using an experimental approach to establish rigorous causality between treatments and outcomes (Fisher, 1947). It most often concerned new seeds released by breeders and new practices proposed by agronomists such as fertilizers and irrigation, and their impacts on yields. But it had been confined to the laboratory and the experiment station. When done in farmers' fields for demonstration purposes, comparative plots were implemented following strict protocols designed by scientists.

The Banerjee-Duflo-Kremer Nobelists made the important contribution of taking the experimental approach to the field under conditions where agency behavior becomes an important contributor to outcomes. Field experiments had been extensively used in medical research. The Nobelists boldly used the approach to rethink how to fight global poverty (Banerjee and Duflo, 2011). They pioneered its application initially to issues of education and health. It quickly spread to all major questions in development economics, including rather naturally agriculture. This new adventure was endorsed by a multitude of research groups and sponsors. With this, a new culture and expertise in field research has emerged, with already major impacts on how to combat global poverty and in particular how to use agriculture for development.

Field experiments in agriculture

Use of field experiments in agriculture is happening at four levels running from the supply side (availability to farmers, knowledge) to the demand side (constraints to adoption, broader transformations). A first level consists in making available to farmers what had been done by scientists under pre-specified conditions: assess the value of new technologies when used by farmers, particularly in terms of profit, food security, and risk. An example is experimentation with flood resilient new rice varieties, with not only a yield advantage under stress but also giving incentives to farmers to invest more in their crops, year-in-year-out, as downside risk has been reduced. Surprisingly, in Odisha where the experiment took place, yield gains from adjusted risk management turned out to be on average of equal magnitude as gains from better

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shock-coping (Emerick et al., 2016). Countless other technologies have been experimented with under farmer agency including laser leveling, soil moisture retention, mechanization, etc.

A second level, also on the supply side, is for the new potentially profitable technologies to be known and understood by farmers so they can decide on adoption. This is difficult in agriculture as farmers are widely dispersed and heterogeneous in the conditions under which they operate, making any extension service of limited effectiveness. This led to search for better entry points in selecting contact farmers to facilitate social learning (Beaman et al., 2019), ways of creating incentives for contact farmers in diffusing information (BenYishay and Mobarak, 2019), approaches to induce community members to seek information from informed farmers (Dar et al., 2019), use of IT services such as phone consultation platforms, customized recommendations based on soil testing, and SMS reminders on when and how to act (Cole and Fernando, 2016).

A third level is to explore the demand-side constraints to adoption of technologies known to farmers. Most remarkable has been to experiment with the design of multiple institutional innovations in pursuit of removing these constraints (Bridle et al., 2018). Major constraints are financial liquidity, exposure to uninsured risks, high costs in accessing markets, and inconsistent decision-making. Examples of such institutional innovations included progress with the design of credit products better customized to the seasonality of agriculture (Burke et al., 2019), linking credit and insurance (Karlan et al., 2014) and making index-based weather insurance into a better product with more effective demand (Carter et al., 2016), reforming markets to improve quality recognition of inputs and products and reduce transaction costs (Bernard et al., 2017), and offering options to contract for nudges facilitating time-consistent decision making in purchasing inputs (Duflo et al., 2011).

A fourth level is to take a broader look at what determines labor productivity in agriculture and well-being in rural areas. The first requires looking at labor calendars and farming systems that keep the land and family labor occupied throughout most of the year in spite of seasonality. This is the agricultural transformation, with the development of value chains, contracts, and links to high value markets (Casaburi and Reed, 2019). The second is the densification of activities in a rural non-farm economy that allows multiple sources of income. This is the rural transformation, with the development of local enterprises processing agricultural products, supplying agriculture with inputs, and delivering consumption goods and services to the rural population. Experimental research on these transformations is incipient and creates new challenges.

Methodological adjustments

Taking the experimental approach from the lab to the field has to confront challenges specific to agriculture which is simultaneously a dimension of nature, a sector of economic activity, and a way of life. This includes, among others, issues of spatial heterogeneity, seasonality and long lags, exposure to random weather shocks and risks, market failures and household decision-making, and difficulties of measurement (de Janvry et al., 2016). We briefly address these in turn to illustrate how the method has been enriched to handle these difficulties.

Spatial heterogeneity. Local agro-ecological and market conditions vary in space, especially under rainfed agriculture that characterizes 95% of Sub-Saharan Africa farming. With heterogeneity, the design of location-specific technological packages is expensive as it limits economies of scale. Implications for the design of experiments include: (1) experimenting over a well-defined and potentially large range of heterogenous contexts; (2) eventually making the observability of heterogeneity directly available to the decision-maker, either directly with leaf color charts that reveal soil conditions and fertilizer deficits, or through third-party services; and (3) when heterogeneity is third-party unobservable, inducing self-selection to help farmers reveal at a cost their types in the dimensions of heterogeneity that matter to the experimenter (Chassang et al. 2019).

Seasonality and long lags. Agriculture follows the seasons and most crops require several months and sometimes years between planting and harvesting. Decisions have to be taken based on expectations at planting time, and can be adjusted as the seasons unfold. Long delays have to be incurred between buying inputs and selling products, creating liquidity problems. Long lags are an invitation to time inconsistencies in decision-making. Implications for the design of experiments include: (1) not isolating crops from the longer cycle in which they are imbedded; (2) experimenting over at least a year which is costly (requiring multiple surveys) and risky as conditions can easily change while the experiment unfolds (cellphone surveys and sensors are useful to achieve more real-time monitoring); and (3) adapting experiments to changing conditions, which challenges the design of blueprint proposals and makes the registration of experiments difficult.

Weather shocks and risk. Outcomes in agriculture depend on weather realizations that can overwhelm and thus obfuscate the experimental determinants. We typically only have limited observations both across space and over time about weather realizations. And weather itself is multidimensional and difficult to characterize. As a consequence, farmers' understanding of the value of an innovation is necessarily highly incomplete, making decision-making about adoption difficult and potentially inducing costly errors. Implications for the design of experiments include: (1) assessing a treatment conditional on the distribution of weather realizations which requires spreading experiments over wide geographic areas and sustaining them over a large number of years (creating difficulties not only with cost and administration of the experiment, but also with the risk of heterogeneity and changes in external conditions); and (2) if learning from others is important in adoption, facilitating information-sharing across locations and time, with a good characterization of prevailing weather and other local conditions.

Other specificities of field experimentation in agriculture. To mention just a few, an important aspect of experimenting with agriculture in farmers' fields is that decision-making is at the household (and possibly community) level, not at the plot level. If markets are failing, and household decision-making implies non-separability between consumption and production decisions, understanding behavior in agriculture requires inserting it into household decision-making with all its multidimensionality of objectives and constraints, and its agency complexity. In this case, field experiments need to collect data not only on the practice under investigation, but also on the many other features of households that affect decision-making on production and consumption. Surveys thus become multidimensional, with risks of inaccuracies, and high cost. The other specificity is difficulty of measurement. This includes such obvious dimensions as inputs used, yields achieved, prices paid and received, the opportunity cost of family labor, the valuation of self-provided inputs and services, and the measurement of quality.

Conclusion

In going from lab to field, experiments have revolutionized a significant part of the research development economists do to understand how agriculture is and can be used for development. The approach has taken them to the field and engaged them into action research with development partners. While only one of several methods available to establish causality, results from field experiments have already had important impacts on evidence-based policy-making, and experiments are getting bolder and larger scale in addressing policy issues. In agriculture, the recipients of the 2019 Nobel Prize in Economics have made the fundamental contribution of helping experimenters jump the fence of the experiment station.

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